

# Benchmark Tests for Stirling Converter Heater Head Life Assessment Conducted

A new in-house test capability has been developed at the NASA Glenn Research Center, where a critical component of the Stirling Radioisotope Generator (SRG) is undergoing extensive testing to aid the development of analytical life prediction methodology (ref. 1) and to experimentally aid in verification of the flight-design component's life. The new facility includes two test rigs that are performing creep testing of the SRG heater head pressure vessel test articles at design temperature and with wall stresses ranging from operating level to seven times that (see the following photograph).



*New facility includes two pneumatic test rigs for elevated temperature creep testing of SRG pressure vessel test articles.*

Long description. A new workbench-sized facility includes two pneumatic test rigs and induction heaters for elevated temperature creep testing of Stirling Radioisotope Generator pressure vessel test articles. The facility is housed within an acrylic safety enclosure.

The SRG is being developed for multimission use, including electric power supply for deep space missions (ref. 2). For this application, the heater head component must endure high temperature for a long time, but at low stress. These conditions impose the life-limiting failure mechanism of material creep, a slow, gradual increase in strain that could eventually end in rupture of the pressure vessel. Because the SRG is required to operate for more than 10 years, creep testing the heater head under prototypical conditions alone would not provide enough timely data to fully complement the analytical effort, nor would it provide the basis for experimental life prediction. Therefore, increasing the test pressure to levels higher than design raises the stress levels of the test articles and accelerates the creep results. In addition, although creep-limited components have been designed satisfactorily using material properties generated from traditional uniaxial tests, the heater head is subjected to a highly biaxial state of stress. To supplement the ongoing uniaxial

creep tests on flight heat Inconel 718 (IN 718) material (ref. 3), the benchmark test program has been designed to experimentally evaluate the response to this specific biaxial stress condition.

Beginning with calibration runs, short-term, high-stress benchmark tests have been conducted on geometrically simplified test vessels fabricated from a heat of flight material to provide early test results; additional calibration runs of 6 months to 1 year in duration are planned for test articles of flight design geometry (see the following photograph on the next page). Also, one "full-up" test will be performed for a flight-design specimen with all structurally significant attachments. This test will be conducted with prototypical internal pressure and additional externally applied axial stress to duplicate actual flight loading.



*IN 718 heater head at 650 °C (1200 °F) with an induction heater coil.*

Long description. Closeup photograph of the 50-millimeter- (2-inch-) diameter by 100-millimeter- (4-inch-) long domed heater head under test at 650 °C (1200 °F). The specimen is glowing throughout the hot end because of resistance to current induced by a surrounding induction heater coil.

The new test facility is located at the Life Prediction Branch's Structural Benchmark Test Facility. The test stand includes two independently operated test rigs with argon pressurization systems capable of 3000 psig, although the test article limit is 1500 psig. Two 3-kW induction power supplies and water-cooled induction coils provide even heating and temperature profiling. A custom data acquisition and control system is employed to safely conduct tests and record results.

This ongoing testing is being performed for the Thermo-Mechanical Systems Branch and the Power and Propulsion Office as part of a Glenn in-house project supporting the development of the SRG. The overall SRG project is managed by the Department of Energy. Lockheed Martin and Stirling Technology Company are developing the SRG for

the Department of Energy. NASA's Office of Space Science is providing technical support to the project through Glenn.

## **References**

1. Halford, G.R., et al.: Structural Analyses of Stirling Power-Convertor Heater Head for Long-Term Reliability, Durability, and Performance. AIP Conf. Proc. 608, 2002, pp. 880-887.
2. Thieme, Lanny G.; and Schreiber, Jeffrey G.: NASA GRC Stirling Technology Development Overview. NASA/TM--2003-212454, 2003.  
<http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2003/TM-2003-212454.html>
3. Bowman, R.R.: Long-Term Creep Assessment of a Thin-Walled Inconel 718 Stirling Power-Convertor Heater Head. Proceedings of the 36th Intersociety Energy Conversion Engineering Conference, vol. 1, ASME, New York, NY, 2001, pp. 435-440.

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**NASA Glenn Research Center** at <http://www.nasa.gov/centers/glenn/home/index.html>  
**Glenn's Thermo-Mechanical Systems Branch** at <http://www.grc.nasa.gov/WWW/tmsb/>  
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